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16. ABSTRACT Pollutant variability in the area represented by a stationary point monitoring site causes an uncertainty in representative sampling. This uncertainty has been determined for selected sites in the Regional Air Pollution Study (RAPS) in St. Louis by using portable sampling and monitoring equipment. RAPS ozone concentrations averaged over twenty minutes are linearly related to the values taken in the surrounding area with almost 1:1 correspondence at both urban and rural sites. Carbon monoxide values are linearly related at the rural site but not at the urban site.					
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Pollutant Variability in the Regional Air Pollution Study

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JOURNAL ARTICLE

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National air quality is currently being established by networks of stationary monitoring sites. The central question related to the use of network data is: "How accurately do the sites represent the area in which they are placed?" The following discussion of data concerns this question. The data

were taken in the Regional Air Pollution Study (RAPS)¹ in St. Louis during the summer "intensive" research periods of 1974-1976.

¹1978-Air Pollution Control Association

Two stations in the Regional Air Monitoring System (RAMS) of the RAPS were chosen, station 105 to represent urban sites and station 108 to represent rural sites. The two sites are shown in Figures 1 and 2. Site 105 is located near the center of St. Louis. A main inter-city street, Broadway, is located approximately 30 meters from the site. Two large factories are located within a 1.0 kilometer radius of the site. Station 108 is located in East St. Louis on farmland near the Mississippi River. Granite City, IL, is to the east at a distance of approximately 3 km. At times, industrial plumes from Granite City carry across the site. Route 3 is located some 200 meters to the east.

The pollutants chosen for monitoring were ozone and carbon monoxide. Different pollutant variabilities were expected for these two gases since one, O_3 , is a secondary pollutant and the other, CO, is a primary pollutant.

Four locations were chosen inside the grid area of the stationary RAMS station and simultaneous readings were made at the station and at these locations. The sampling locations are depicted by the symbols A, B, C and D in Figures 1 and 2. The sites are all approximately 1 km from the RAMS station.



Figure 1. Site 105 in the Regional Air Monitoring System (RAMS); locations A, B, C, and D mark portable monitoring sites.

In the case of O_3 , monitoring instrumentation consisted of two portable O_3 monitors.² These monitors were normalized to the RAMS monitor by side-by-side comparisons before and after the tests. Monitor drift due to temperature effects was accounted for by scaling data according to any offsets observed in the before and after comparisons. For CO monitoring, Tedlar bag samples were taken at the four locations and analyzed with a gas filter correlation monitor.³ This monitor was housed in a mobile van in which temperature variations were minimized to $\pm 5^\circ C$.

In both the CO and O_3 monitoring sequences, 20 min averages were obtained. All monitoring sequences were performed between 0700 and 1700 CST, the peak monitoring activity being the 0900-1000 and 1200-1300 hr. Sampling sequences occurred during 38 different days. In a typical monitoring sequence, ambient samples were taken sin. It a-

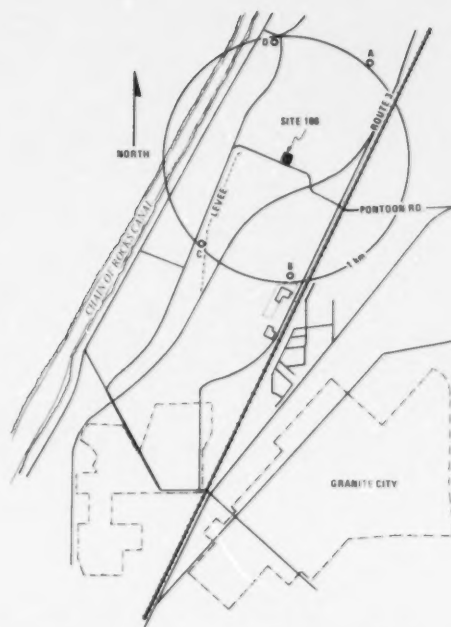


Figure 2. Site 108 in the Regional Air Monitoring System (RAMS); A, B, C, and D mark portable monitoring sites.

neously at two of the four area locations as well as at the RAMS station. After the monitoring apparatus was moved to the remaining two locations, the sampling procedure was repeated. Subsequently, data taken at the RAMS station were averaged and compared with the readings taken at each individual area location. As an example of graphical representation of the measurements, O_3 data for all five locations are shown in Figure 3. No area site bias is evident.

As a first attempt at analysis, the RAMS site data and the data taken within the surrounding area were plotted graphically and a linear regression analysis was performed. Table I summarizes the results and gives a number of test statistics to characterize the data.⁴ The standard error of the estimate,

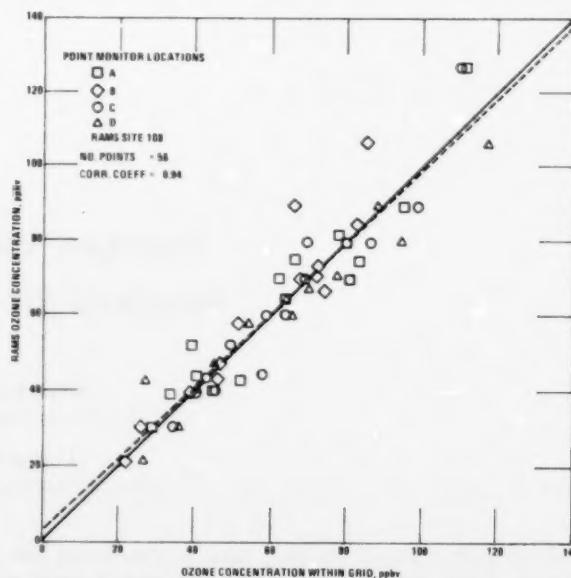


Figure 3. Scatter diagram of ambient ozone concentrations at RAMS site 108 showing the RAMS reading versus those obtained at the portable monitoring sites. Dotted line gives linear regression result.

$s_{y,x}$, is given as a measure of variability about the regression line; s_0 and s_1 , the standard errors of the regression coefficients a_0 and a_1 , respectively, provide a basis to test the significance of the regression line. The correlation coefficient, r , and the coefficient of determination, r^2 , can be used to characterize the strength of the linear relationship between the RAMS reading and the grid site readings.

The O_3 concentrations at locations within the grid areas of both RAMS stations were similar to those measured at the parent stations. Mean values at the RAMS and the area sites were approximately equal indicating the absence of inherent

Table I. Summary of pollutant variability data.^a

Station	Ozone, ppb		Carbon monoxide, ppm	
	108	105	108	105
No. points	58	52	56	70
$\bar{x}$ (area)	62.4	54.4	0.41	1.09
$\bar{y}$ (station)	63.1	51.3	0.26	0.58
r	0.94	0.85	0.80	0.12
a_0	1.77	3.53	-0.01	0.50
a_1	0.98	0.88	0.67	0.07
$s_{y,x}$	8.44	10.72	0.12	0.35
s_0	3.25	4.43	0.03	0.09
s_1	0.05	0.08	0.07	0.07
r^2	0.88	0.72	0.64	0.01

^aWhere RAMS reading = a_1 (grid site reading) + a_0 .

or sampling differences. No systematic bias due to siting was noted at site 108 since slope and intercept values are almost equal to 1.0 and 0.0, respectively. At site 105, more scatter was evident in the data, as expected at an urban site because of the presence of automobile exhaust and the attendant O_3 , NO reaction. A systematic departure from 1-1 correspondence is evident at site 105, where the RAMS station reads lower than the remote sites.

CO concentrations within the two grid areas were not well represented by the RAMS stations. Correlation of CO values between remote and RAMS readings is sufficiently low for station 105 that the linear regression analysis is of no value.

In general, values of CO concentration recorded at remote sites were higher than those taken at the RAMS station. More detailed analysis of the data indicated that a portion of the disparity was related to the sampling technique used in the RAMS.⁵ From this study it was concluded that a discrete sampling technique such as that being used in the RAMS was subject to errors in representative sampling and that these errors would be evident during sampling periods on the order of 20 min as apparent low readings when compared to the time-integrated average.

To separate that part of the apparent disparity due to sampling technique from the variability due to location, bag samples (20 min) were taken at the RAMS manifold inlet and compared to samples taken at the four area locations. The results are shown in Table II. In the process of examining these data, one location at site 108 (location A) was determined to be source-dominated for CO and was deleted from Table I and II results. The agreement between area and station values was thus enhanced significantly.

The differences in point and area monitoring of CO at sites 108 and 105 are evidently due either to sampling technique or to instrument malfunction. The CO data in Table II (using bag samples) agree, but CO data from Table I do not agree nearly as well. The average concentration monitored at remote locations are almost a factor of 2 greater than those at the RAMS. CO readings at the RAMS stations and area locations are more highly correlated at station 108 than at station 105.

At site 108, a linear relationship exists between CO readings at the grid locations and those at the RAMS.

In conclusion the following summary statements can be made:

1. The agreement between 20 min point samples of O_3 at sites 105 and 108 are given by the equations:

$$\text{RAMS} = 0.88 (\pm 0.10) \text{ area site} + 0.004 (\pm 0.006) \text{ at station 105}$$

$$\text{RAMS} = 0.98 (\pm 0.07) \text{ area site} + 0.002 (\pm 0.004) \text{ at station 108}$$

where the uncertainty (brackets) is characterized by the 80% confidence limits. Note that the intercept values are not significantly different from zero so that zero concentration levels for the two instruments are consistent.

2. The relationship between 20 min point samples of CO at site 108, after elimination of the readings from a source-dominated area location was linear, i.e.

$$\text{RAMS} = 0.67 (\pm 0.09) \text{ area site} - 0.01 (\pm 0.04) \text{ at station 108.}$$

If the sampling error was eliminated by using bag samples at the station, the relationship improved to

$$\text{RAMS} = 0.94 (\pm 0.06) \text{ area site} - 0.004 (\pm 0.03) \text{ at station 108.}$$

The lack of agreement between area and point samples of CO at station 105 is evident from the equation:

$$\text{RAMS} = 0.07 (\pm 0.09) \text{ area site} + 0.5 (\pm 0.12) \text{ at station 105.}$$

If the sampling error was eliminated by using bag samples at the station, the relationship improved to

$$\text{RAMS} = 0.30 (\pm 0.52) \text{ area site} + 0.75 (\pm 0.07) \text{ at station 105.}$$

Table II. Carbon monoxide variability using bag samples (ppm).^a

Station	108	105
No. points	33	40
$\bar{x}$ (area)	0.41	1.12
$\bar{y}$ (station)	0.38	1.01
r	0.94	0.60
a_0	-0.004	0.75
a_1	0.94	0.30
$s_{y,x}$	0.085	0.197
s_0	0.029	0.068
s_1	0.059	0.521
r^2	0.89	0.36

^aWhere RAMS reading = a_1 (grid site reading) + a_0 .

No evidence of a difference in variability was found at the area sites around station 105, i.e., grid sites A, B, C, and D were equivalent. The fact that the station 108 intercept values are essentially zero suggests that there is no zero bias caused by an impurity in the zero gas and that the conclusion of low correlation at station 105 is correct.

These comparisons should prove useful in characterizing the variability expected between area average readings and RAMS readings. For example, model predictions of 20 min averages in the RAMS can be expected to agree with RAMS readings within an interval characterized by the standard errors given in Table I. Two important implications result from these pollutant variability studies: (1) Model validation for CO and other source-related pollutants should be done by an integrated path measurement of the type available using a diode laser.⁶ (2) Other source-related pollutants such as NO and various hydrocarbons are expected to be as variable as CO.

APCA NOTE-BOOK

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